C.1 Introduction

The purpose of the Proof of Principle Testing for the Silos Project at the Fernald Environmental Management Project (FEMP) is to perform rigorous testing of proven and commercially available remediation technologies to evaluate their potential use for treatment of Silos 1 and 2 residue. The testing shall be focused on meeting the regulatory, processing, storage, transportation, and disposal requirements of the Silos 1 and 2 residue.

The following are the specific technology families:

- Vitrification by a Joule-Heated Technology;
- Vitrification by a Non-Joule Heated Technology;
- Remediation by a Cement-Based Technology; and
- Remediation by Another Chemical-Based Technology.

This testing, conducted by the successful Seller, shall be performed using nonradioactive surrogates which simulate the physical and chemical characteristics of the residue in Silos 1 and 2. The results of this testing will provide FDF technology-specific information on safety, reliability, implementability, cost, and schedule. Additionally, this information will be used to support revision of the Operable Unit 4 (OU4) Feasibility Study (FS) and, ultimately, support the OU4 Record of Decision (ROD) amendment. Furthermore, these results will support the development of preliminary design data for a remediation facility for each technology.

C.2 Background

Silos 1 and 2, which are components of OU4, were constructed in 1951 and used for storage of radium-bearing residue resulting from uranium ore processing. Silo 1 contains approximately 3,300 cubic meters (m^3) of residue and Silo 2 contains approximately 2,800 m^3 of residue.

The composition of the residue in Silos 1 and 2 is primarily a wet, gray, silty clay with an average moisture content of 30 weight percent (wt%)[1]. Present within the residue of the two silos are in excess of 3700 Curies (Ci) of Ra-226, 1900 Ci of Pb-210, and 600 Ci of Th-230. Other significant metals include more than 129.8 tons of barium, 913 tons of lead, 2.86 tons of arsenic, uranium (U-238), and small quantities of gold. Additionally, the silos residue may contain detectable levels of the Polychlorinated Biphenyls (PCBs) Aroclor-1248, Aroclor-1257, and Aroclor-1260, as well as tributyl phosphate.

The silos residue is classified as a byproduct material as defined under Section 11(e)(2) of the Atomic Energy Act (AEA) of 1954, as amended. Under this classification, it is excluded from regulation as solid or hazardous waste under the Resource Conservation and Recovery Act (RCRA). However, available analyses of the residue indicate that the levels of lead are in excess of the TCLP limits. Therefore, the OU4 ROD identified certain requirements of RCRA as relevant and appropriate, including the requirement that the residue be treated such that it no longer exhibits a hazardous characteristic.

Radon-226 and the daughter products resulting from its decay, primarily Radon-222, are the nuclides of concern from a health and environmental perspective. Radon-222 is known to be emanating from the silos through cracks and structural joints. This presents a retrieval and treatment challenge in that the silos headspace radon concentrations are in the 8-11 million pico Curies/liter (pCi/l) range as the silos currently exist. Radon is relatively mobile and capable of migrating through air and water. The selected treatment process and supporting operations shall be designed to support radon control / treatment and have the capability to process the residue in a slurry form. Previous experience with transferring the silo surrogates through the pilot plant systems demonstrated that slurries up to 30 wt% solids could be successfully handled. Higher percent solids led to frequent blockages in the piping and tanks. Therefore, 30 wt% solids is the target.

---

[1] Weight percent moisture refers to the amount of free water or loosely bonded water in the residue or surrogate.

As part of the Silos 1 and 2 Removal Action [as defined by the Consent Agreement As Amended Under CERCLA (Comprehensive Environmental Response, Compensation and Liability Act as amended) Sections 120 and 106(a)], a layer of BentoGrout™ was placed over the K-65 residue in Silos 1 and 2 to attenuate Radon-222 emissions from the silos. There is approximately 380 m^3 of BentoGrout™ in Silo 1 and 300 m^3 of BentoGrout™ in Silo 2. The combined amount of residue and BentoGrout™ in Silos 1 and 2 totals approximately 6780 m^3.

Additional information concerning the characterization of the Silos 1 and 2 residue is provided in Appendix A of this document.

C.3 Project Scope

Proof of Principle Testing shall provide data that indicates whether the various technologies produce a treated surrogate that meets the performance requirements defined in Section C.4. The treatment technology shall remediate the surrogate slurries and produce treated waste (surrogate) forms that meet all criteria for final, off-site disposal and require no additional treatment. The treatment technology shall be demonstrated as a process that is safe to the environment, the public, and human health.

Proof of Principle Testing shall be performed at the Seller's testing facility with Fluor Daniel Fernald (FDF) specified Silos 1 and 2 nonradioactive, surrogate slurries. The data collected from the Proof of Principle Testing shall be presented in the final report and shall consist of a test description including objectives and rationale, experiment/demonstration design and procedures, sampling and analysis data, test results, and conclusions. The final report shall also provide design data for a proposed layout of a full-scale remediation facility and a process flow diagram for the primary waste stream. The scope of the design is limited to the treatment facility and secondary waste stream treatment systems. Retrieval of the Silos 1 and 2 residue is addressed in a different contract.

C.3.1 General Work Description

FDF will provide the Seller the Proof of Principle Testing specifications including, but not limited to: three surrogate formulas, compound specifications, slurry preparation requirements, testing guidelines, and treated surrogate standards and requirements.

The three surrogate formulas that FDF is providing the Seller are presented in Table C3-1.

Table C3-1: FDF-Provided Surrogate Formulas

Formula Name	Formula Description
Demonstration Surrogate	Simulation of Silo 1 residue spiked with the concentrations heavy metals present in Silo 2 residue
Silo 1 Surrogate	Simulation of Silo 1 Residue
Silo 2 Surrogate	Simulation of Silo 2 Residue

The Seller shall develop treatment recipes for the three surrogate formulas on a laboratory scale. Only the treatment recipe for the demonstration surrogate shall be utilized in a continuous 72-hour demonstration run. Treatment recipes for the other two surrogate formulas shall be tested on the laboratory scale only.

Data collection and recording requirements shall include at a minimum: residue flow rates and concentrations, secondary waste stream composition and concentrations, sampling and analysis, technology-specific treatment parameters, container/ packaging characterization and waste loading/bulking factors. The Seller shall document on video tape the entire demonstration run and provide a copy of the video tape(s) to FDF.

Prior to the initiation of the actual Proof of Principle Testing, the Seller is required to submit and obtain FDF's concurrence on a Work Plan that details the program by which the demonstration and laboratory testing shall be conducted and documented. FDF will indicate hold points and witnessing sessions during the Proof of Principle Testing during the review process.

The Seller shall be responsible for the procurement of all necessary chemicals, including the compounds for the surrogate; materials for the Proof of Principle Testing, including testing equipment, supplies, and video tapes; and the disposal of all treated surrogates, secondary waste streams, and excess chemicals and materials in accordance with all applicable federal, state, and local regulations. The Seller shall perform all activities safely, without causing harm to the public, human health or the environment; and in compliance with all federal, state, and local laws.

C.3.1.1 FDF Project Personnel

During the Proof of Principle Testing, the Seller shall keep FDF informed of the progress through weekly teleconferences and reporting. The FDF Technical Representative for the Silos 1 and 2 project is the FDF Silos 1 and 2 Project Manager. In addition to interfacing with the Seller, the FDF Technical Representative will be responsible for participating in meetings with regulators and stakeholders in order to keep interested parties informed of the Proof of Principle Testing progress.

C.3.2 Pre-performance Activities

C.3.2.1 Work Plan

During the planning phase of the project, the Seller shall develop the Work Plan in accordance with the guidelines provided in Appendix B. The Work Plan shall address treatment recipe development, testing, sampling, and analysis quality assurance controls for work supporting the Proof of Principle Testing. The Work Plan shall be submitted to FDF for concurrence as a prerequisite for the initiation of testing-related activities.

C.3.2.2 Testing Quality Assurance / Quality Control Plan

During the planning phase of the project, the Seller shall prepare a Testing Quality Assurance / Quality Control (QA/QC) Plan that contains the elements identified in Appendix D. The Testing QA/QC Plan shall present programmatic controls and verification of the Work Plan activities. Once the Testing QA/QC Plan is developed, the Seller shall submit it to FDF for concurrence as a prerequisite for the start of the testing.

C.3.2.3 Surrogate Ingredients

During the planning phase of the project, the Seller shall purchase the chemical compounds required for the Proof of Principle tests. Surrogate ingredient specifications are provided in Appendix C. The Seller shall perform sieve tests and submit compound assays. FDF will accept material certificates for each compound in accordance with the schedule in Section C.6. The Seller shall have Material Safety Data Sheets (MSDS) readily available at the testing site for all chemical compounds to be used.

C.3.3 Performance Activities

C.3.3.1 Surrogate Preparation

The Seller shall prepare the surrogate slurry in accordance with the specifications in Section C.4. The Seller shall notify FDF of the surrogate slurry preparation schedule. The Seller shall then provide FDF the opportunity to collect or witness the collection of independent samples of the chemical compounds and blended surrogate slurries prior to the initiation of development and/or testing. FDF will respond with analytical results to the Seller within seven working days of receipt of the slurry sample at the analytical laboratory. Once the samples are collected for FDF analysis, the Seller shall be able to proceed at the Seller's risk of having to re-start the testing or demonstration. If FDF determines that the analytical results indicate the surrogate slurry does not meet the slurry specifications, the Seller shall be required to either adjust the surrogate slurry or prepare a new batch and repeat any testing previously performed. FDF will have the option to re-sample and analyze the surrogate slurries after adjustments or new batch preparation.

C.3.3.2 Perform Proof of Principle Testing

The Seller shall perform Proof of Principle Testing in accordance with the approved Work Plan and test procedures. Procedures shall address all operation activities required to perform Proof of Principle Testing. Sampling procedures shall be developed based on the applicable ASTM procedures for sampling solid, slurry, and aqueous materials. The test procedures shall be prepared such that all the personnel performing the Proof of Principle Testing shall be able to perform tasks correctly and safely. The Seller shall update FDF on the process of the testing via telephone conversations and weekly, one to three-page reports. The Seller has the option to use video tapes to enhance the communications. FDF will have the option to conduct witnessing visits, coordinated with the Seller, during the different phases of the Proof of Principle Testing. At a minimum, FDF will visit the Seller's office after award of the Contract and the Seller's testing laboratory during the development of the treatment recipes and the demonstration facility during the 72-hour process demonstration. The Seller shall be responsible for the video taping of the 72-hour process demonstration.

C.3.3.3 Data Collection Points / Data Collection Needs

The Seller shall collect sufficient samples to provide FDF with a thorough and comprehensive description of the treatment technology process and any associated pre-treatment and post-treatment processes. The sampling frequency and locations shall be based upon the treatment technology; configuration of the testing process; and the quantity, type, and container size of samples.

The sampling and analysis program shall be thoroughly described in the proposal to provide FDF a sufficient level of confidence that the Seller shall be able to provide the necessary analytical data at the conclusion of the project. The sample points, sample frequency, and analytical methods shall be identified in the Sampling Plan section of the Work Plan.

In the Work Plan, the Seller shall identify and be responsible for the performance of all chemical and physical tests that are relevant to the specific treatment technology. During the Work Plan review, FDF will have the option to require additional sampling and analysis, if FDF determines that the Seller-proposed analysis is insufficient to meet the goals of the project as defined in this document. FDF has the option to witness the collection of independent samples at any point in the development and testing effort and have the samples analyzed at an analytical laboratory of their selection with no cost to the Seller.

C.3.4 Analysis

C.3.4.1 Analytical Laboratory

The analytical laboratory analysis of the Seller-collected samples shall be performed in accordance with the analytical methods specified in the Work Plan. Seller-collected samples that support laboratory-scale development of the treatment recipes may be analyzed at a Seller-selected analytical laboratory. Seller-collected samples whose analytical data will be reported to FDF to verify surrogate preparation, document treated surrogate performance, or to support the revision of the FS shall be analyzed at one of the FDF-approved laboratories identified in Section J. The analytical data packages supporting the results shall be included as an attachment to the final report.

C.3.4.2 Data Collection / Management

The Seller shall collect and document testing and analytical data in accordance with the Data Management Plan to be developed as part of the Work Plan. The Seller shall provide FDF with copies of the validated data as an attachment to the final report.

C.3.4.3 Data Evaluation

The Seller shall evaluate the testing and analytical data in accordance with the Data Analysis, Evaluation, and Interpretation sections of the Work Plan. The type and amount of data collected and the frequency of evaluation shall be such that the Seller can perform testing that meets the FDF data needs and shall be specified in the Sampling Data Collection and Analysis Plan of the Work Plan.

C.3.4.4 Mass and Energy Balance

For the demonstration run, the Seller shall calculate a mass and energy balance for each unit operation and submit the information as a section of the final report. For the purposes of Proof of Principle Testing, heat/energy and material/mass balance shall contain for all inlet and outlet process flow streams the following parameters: temperature, pressure, components, concentrations, and flow rates. The Seller shall include the calculations of the amount (generation rate) and composition of each secondary waste stream as well as the primary treatment stream.

C.3.5 Information for Preliminary Design Data

After the completion of the Proof of Principle Testing and associated analytical analysis, the Seller shall provide design data, including mass and energy balances, that supports an FDF-prepared Design Basis of a Full-Scale Remediation Facility. The design data shall include the elements identified in Appendix F, Table F2.

C.4 Requirements and Specifications

C.4.1 Surrogate Formulas and Treatment Recipes

As identified in Table C3-1, FDF provides the Seller three nonradioactive surrogate formulas that simulate the chemical characteristics of Silos 1 and 2 residue. The formulas and the formula preparation procedure are presented in Appendix C. The Seller shall develop and optimize two treatment recipes for each surrogate formula: one formulated to meet the present RCRA Toxicity Characteristic (TC) limits and one formulated to meet the proposed RCRA Universal Treatment Standards (UTS). The Seller shall identify the optimized treatment recipe in accordance with the identification scheme presented in Table C4-1.

Table C4-1: Required Treatment Recipes

Surrogate Name	Treatment Recipe Name	
	Present TC limits	**Proposed UTS limits***
Demonstration Surrogate	SO-D	*SO-U*
Silo 1 Surrogate	S1-T	*S1-U*
Silo 2 Surrogate	S2-T	*S2-U*

* - If the waste loading is not significantly impacted for the technology being demonstrated, then only treatment recipes for the present TC limits need to be developed and tested.

C.4.1.1 Compound Specifications

To ensure that each Seller is performing the Proof of Principle Testing with the same surrogates, FDF has developed specifications for compounds identified in the surrogate formulas which are presented in Tables C1, C2, and C3 in Appendix C. The Seller shall be responsible for performing elemental analysis and sieve testing on the surrogates to provide analytical data which verifies that the surrogates meet FDF specifications.

C.4.1.2 Surrogate Slurry Characteristics

The Seller shall prepare the surrogate slurries in accordance with the procedure and requirements in Appendix C. The preparation of each batch of surrogate slurry shall be documented in a laboratory log book. Once the slurry is prepared and treated, the Seller shall calculate the waste loading and bulking factor of the treated surrogate. The Seller shall utilize the formulas for waste loading and bulking factor presented in Appendix C.

C.4.2 Seller Testing

C.4.2.1 Laboratory Scale Development

Surrogate slurry formulas for Silo 1 residue and Silo 2 residue are provided in Tables C2 and C3 in Appendix C. The Seller shall develop treatment recipes for these surrogates on a laboratory scale. The objective of the laboratory-scale development of treatment recipes is to identify the remediation recipe that meets the current TC regulatory limits; and, to determine the impact meeting the UTS, as presented in Table 4.2, has on the treatment recipe and waste loading. A total of six treatment recipes shall be developed at a laboratory scale: TC and UTS for Silo 1 surrogate slurry, TC and UTS for Silo 2 surrogate slurry, and TC and UTS for the demonstration surrogate. The treatment recipe for TC on the demonstration surrogate slurry shall be utilized during the 72-hour demonstration.

Development of the treatment recipes shall be performed according to a controlled, planned method that shall be specified in the Work Plan. Each treatment recipe tested shall be documented along with testing and evaluation of the resulting batch of treated surrogate. The Seller shall collect samples of treated surrogate slurry and be responsible for the performance of TCLP analysis. The results of the TCLP will be evaluated against the current TC limits and the anticipated UTS limits in accordance with the Sample Plan section of the approved Work Plan. The Seller shall record and justify adjustments to the treatment recipe in laboratory logbooks. The Seller shall update FDF on the laboratory testing progress on a weekly basis. FDF has the option to witness laboratory testing and to have samples collected for independent analysis at no cost to the Seller.

The Seller shall prepare and collect samples for durability testing in accordance with Table G1 in Appendix G. The Contractor will submit these samples to FDF, who will be responsible for performing the testing and analysis.

C.4.2.2 Demonstration of Process

The Seller shall perform Proof of Principle Testing, as described in the Work Plan, which demonstrates that the treatment technology can produce a treated waste (surrogate) form that consistently meets the criteria as defined in Section C.4.2.3. The video taped demonstration shall be operated at a production rate that provides FDF confidence that the process can be scaled-up to treat the Silos 1 and 2 residue during 36 months of operations. A scale-up configuration using multiple process lines is acceptable and may enhance reliability, availability, and maintainability of the full-scale process. The Proof of Principle Testing shall demonstrate the balance between optimal waste loading and processibility of the waste stream. The following parameters define the Proof of Principle Testing Demonstration Target Parameters:

- Duration - Demonstration of the process with the demonstration surrogate shall be performed over a continuous 72-hour period. Surrogate slurry preparation in accordance with the provided formula in Table C1 shall be performed prior to the initiation of the 72-hour demonstration period. Pre-treatment can be performed prior to and during the demonstration period, based on process requirements. Unplanned downtime greater than 3.5 hrs. (± 5%) shall require restart of the demonstration and a new 72-hour demonstration period. Unplanned downtime less than 3.5 hrs. (± 5%) shall be considered part of the 72-hour demonstration period. In addition to the duration of each unplanned downtime, the root cause of each downtime shall be investigated and the results documented in a test log.

- Quantity - Demonstration shall process, at a minimum, approximately 2600 kilograms of the surrogate slurry (30 wt%) solids during each 24-hour period.

- Batches - The Proof of Principle Testing shall be performed in a minimum of 10 batches (or defined populations in a continuous process) to obtain sufficient data to provide assurance of reliability of the process. A population may be defined by the volume of the tank or reservoir that feeds or supplies surrogate slurry to the treatment unit in the case of a continuous process. In a continuous process, a population may be defined by the switching between feed tanks or reservoirs.

- Samples - During the Proof of Principle Testing, representative samples of each batch of pre-treated surrogate, in-process surrogate, treated surrogate, and secondary waste streams shall be collected in accordance with the Sampling, Data Collection, and Analysis Plan sections of the Work Plan. Once a sample is collected from each of the 10 batches or populations of treated surrogate, the Seller shall select three samples and submit them for TCLP analysis. FDF has the option to either randomly select the three samples or concur on the three samples the Seller randomly selects. The Seller shall archive the remaining samples of the treated surrogate which shall be transferred to FDF with the final report Additionally, the Seller shall prepare and collect samples for durability testing in accordance with Table G1 in Appendix G. The Contractor will submit these samples to FDF, who will be responsible for performing the testing and analysis at no cost to the Seller.

- Analysis - Representative samples of the treated surrogate shall be analyzed in accordance with the Work Plan. Samples from each batch shall submitted for the analytical analyses and physical tests required to meet the acceptance criteria presented in Section C.4.2.3.

- Process - The Proof of Principle Testing shall be performed either in batches or continuously, based on the type of process that would be utilized in a full-scale remediation facility for the treatment technology.

- Equipment - The Proof of Principle Testing shall be performed with equipment that is representative of the equipment that would be utilized in a full-scale remediation facility for the treatment technology.

The Proof of Principle Testing demonstration parameters shall be developed based on the technology and facility. If the Seller believes the parameters specified above can not be reasonably met due to the scale of the test facility or the nature of the technology, the Seller may present alternative demonstration parameters to FDF for consideration in the proposal. If FDF concurs with the proposed alternative parameters, FDF will provide the Seller with written approval.

C.4.2.3 Performance of Testing for Treatment Requirements

C.4.2.3.1 Seller Testing

The treated surrogate shall pass the following tests:

A. Appearance The treated surrogate residue shall appear uniform and homogeneous to non-magnified vision. Lumps, pockets of unmixed wastes (surrogate), layers, etc. will be considered failures.

B. Compressive Strength Compressive strengths of at least 50 psi per ASTM C39.

C. No liquids Contain no free standing liquids per ANS 55.1.

D. TCLP Perform the TCLP for the metals listed in Table 4-2. TCLP analysis shall be performed on samples of treated surrogate that have been aged for 28 days. Passing concentrations shall be less than 50% of the RCRA limit. Current applicable and anticipated regulatory limits for the analytical results of the United States Environmental Protection Agency (U.S. EPA) TCLP are provided in Table C4-2.

In addition to the current TC metals, testing shall also be performed for the additional metals listed in Table C4-2. There are no current standards for these additional metals but the additional data will provide a basis for comparison of treating Silos 1 and 2 residue to meet the TCLP and UTS standards.

E. Dusting / Particulate. Fine particulate surrogate shall be immobilized so that the treated surrogate disposal package contains no more than 1 wt% of less-than-10 micrometer - diameter particles, or 15 wt% of less-than-200 micrometer-diameter particles. Residues that are known to be in a fine particulate form or in a form that could be mechanically or chemically transformed to a particulate during handling and interim storage shall be immobilized.

Table C4-2: RCRA Treatment Standards

Constituent	Current Regulatory Limit (PPM TCLP)	Proposed UTS Regulatory Limit (PPM TCLP)
Arsenic (As)	5.0	5.0
Barium (Ba)	100.0	21
Cadmium (Cd)	1.0	0.20
Chromium (Cr)	5.0	0.85
Lead (Pb)	5.0	0.75
Mercury (Hg)	0.20	0.20
Selenium (Se)	1.0	5.7
Silver (Ag)	5.0	0.11
Antimony (Sb)	--	0.07
Beryllium (Be)	--	0.02
Nickel (Ni)	--	13.6
Thallium (Th)	--	0.20
Vanadium (V)	--	1.6
Zinc (Zn)	--	4.3

The proposed UTS limits in Table C4-2 are provided for evaluation since future regulation may impose this more restrictive limit. The ability of a candidate technology to pass the anticipated TC limits will be the prime consideration.

F. RCRA Characteristics. The treated waste form shall not exhibit a characteristic of a hazardous waste as defined by 40 Code of Federal Regulations (CFR) 261 Subpart C - Characteristics of Hazardous Waste (261.20 through 261.24). Nor shall treated waste be listed as hazardous waste.

C.4.2.3.2 FDF Durability Testing

The Seller shall supply samples of the treated surrogate for FDF durability testing. Samples shall be supplied in accordance with the sampling schedule give in Table G-1 in Appendix G. Example of tests that may be performed on the treated surrogate are:

- **Leach Immersion** -- This test normally immerses cylinder samples in demineralized water or appropriate leachate for 90 days. This test is performed in accordance with ANSI 16.1 and analyzed for leached constituents.

- **Shrinking Unreacted Core (SUC) Leach Test** -- This test determines the leach rate at the surface of the treated waste over time. It determines if chemical depletion or the formation films, etc., on the surface of the treated surrogate either decrease or increase the leach rate with time. The test is often run at different pH leachates to better model leaching.

- **Wetting and Drying Testing** -- This test covers procedures for determining material and physical strength losses produced by repeated wetting and drying of solid specimens. It also covers the visual observation of the disintegration of solid specimens. The test shall be performed in accordance with ASTM D 4843-88.

C.4.2.4 Treated Surrogate / Production Characteristics

The following treated surrogate and production characteristics, as defined in Table F3 in Appendix F, shall be considered and qualitatively discussed in the Seller's final report:

A. Optimization of waste loading with respect to operating efficiency;
B. Percentage and cost of additives;
C. Ease of forming treated waste (treated surrogate) into disposable pieces or placing into disposal containers that are sufficient for over-the-road transport;
D. Ease of process -- most versatile and robust;
E. Maintenance Records; and
F. Direct disposal readiness, without additional treatment, of the treated surrogate at a facility with the acceptance criteria identified in Section C.4.2.3. The treatment process shall not be an interim process.

C.4.3 Design Data and Design Requirements

C.4.3.1 Design Data

The Seller shall be required to provide FDF with all items identified in Table F2 of Appendix F. The design data provided shall support preliminary FDF Design Basis of a full-scale remediation facility. To be considered a full-scale remediation facility, the Seller-provided preliminary design data shall define a facility that can support the treatment of the Silo 1 and Silo 2 residue in an operation period of approximately 36 months.

C.4.3.2 Process Description

The Seller shall prepare a detailed description of the proposed technology that addresses all items outlined in the Process Description block of Table F2. The description shall include all components of the treatment steps, pre-treatment steps, and post-treatment steps (a.k.a. the primary process line). The Seller shall also provide discussion of any items unique to the proposed technology not listed in Table F2.

C.4.3.3 Environmental Regulatory Requirements and Guidelines for Design

The design data for the treatment process proposed by the Seller shall result in production of a treated surrogate form that meets the criteria specified in Section C.4.2.3. The design data shall preclude or minimize environmental releases of hazardous substances from the process. The design data shall allow for recycling of secondary waste generated during the process, including reprocessing any treated residue that does not meet the disposal criteria. Generation of secondary waste, including wastewater, shall be minimized. Key requirements are summarized in the following discussion.

Waste Acceptance Criteria

The key criteria for the treated residue requires that the remediation treatment process shall convert untreated Silos 1 and 2 residue into a treated waste form that meets the requirements listed in Section C.4.2.3.

Air Emissions Control

Equipment selection/design and design of the full-scale remediation facility shall include enclosed systems and other controls which preclude or limit release of gaseous and particulate radionuclides, and other air contaminants to the environment. Point source off-gas control systems used in remediation shall use Best Available Technology (BAT). For emissions of particulate material, high efficiency particulate air (HEPA) filtration shall be considered BAT.

Wastewater Control

The conceptual treatment process shall be designed to either eliminate the generation of wastewater or recycle wastewater produced during the treatment process, in order to minimize the amount of wastewater that must be treated by the FEMP Advanced Wastewater Treatment (AWWT) system. Minimizing or recycling the wastewater generated by secondary processes, such as quenching of off-gas, shall also be considered. The site AWWT is an advanced wastewater treatment system designed to remove uranium ions from aqueous waste streams. The process includes settling, filtration, and ion exchange using selective media. Since there are no "pretreatment criteria" for the AWWT, acceptability of a wastewater stream at the AWWT shall be on a case by case basis.

The Seller shall assume that some pretreatment of project wastewater would most likely be needed, probably filtration for removal of total suspended solids (TSS), and/or some treatment for dissolved radon. All wastewater must be staged for characterization prior to batch discharge to the AWWT. Dilution, as a substitute to treatment, shall not be allowed.

Specific guidance and criteria for project wastewater include:

- No listed hazardous waste, as defined under RCRA, may be discharged in the wastewater. Wastewater that exhibits a characteristic of hazardous waste for metals would likely require pretreatment;

- Discharge of TSS in excess of 1,000 ppm shall not be allowed;

- Wastewater discharges shall be monitored and reported to FDF for the following constituents:

Arsenic	Lead	Total Dissolved Uranium
Barium	Selenium	Chloride
Cadmium	Radium-226	Nitrates
Chromium	Thorium-230	

- All wastewater discharged shall be metered with a flow measuring and recording device. Metering shall include measurement of total flow.

Secondary Waste Management

Design of the remediation process shall minimize the generation of secondary waste and allow waste recycling back into the treatment process, to the extent practical. Secondary waste includes wastewater, solid waste, hazardous waste, new radioactive waste, spent filters, etc. Waste management includes waste characterization, staging, segregation and containment, any necessary treatment, and disposal. Mixing or blending for the purpose of diluting characteristically hazardous waste to render it non-hazardous is prohibited.

Sampling and Analysis

The Seller shall develop and document a sampling and analysis program to be included in the proposal. The following items shall be included in the program description:

- the proposed sampling frequency;
- the proposed analytical tests; and
- the rationale supporting the approach.

The Seller shall provide enough detail for FDF to develop a high level of confidence that the Seller will provide the sufficient amount of data upon the completion of the project. The design shall allow process control sampling and analysis of the treated waste, and also facilitate monitoring of environmental emissions. Samples of the treated surrogate shall be collected and analyzed to verify that the treated surrogate meets the treatment requirements in Section C.4.2.3. Secondary waste generated during the process shall also be sampled and analyzed to support treatment and disposal efforts.

C.4.3.4 Schedule

The Seller shall provide FDF information to support the development of a schedule for the remediation of Silos 1 and 2 residues. The Seller shall include the estimated time required for design, construction, startup, and operation of the full-scale remediation facility. The Seller shall identify any long-lead time items that will impact the procurement phase of the project. The Seller shall estimate each activity in monthly increments and summarize the information in a tabular format. The Seller shall also support the estimates with a break down of key activities in each phase.

C.4.3.5 Process Area General Arrangement Diagram

General Arrangement (GA) drawings provided by the Seller shall show the layout of the main process line. The GA drawings shall include size and relative arrangement of all major equipment required for the proposed technology (including all pre-treatment steps). The Seller shall be required to provide Process Data Sheets for all major equipment detailing the equipment size, material and cost. A typical Process Data Sheet format is provided in Appendix F.

C.4.3.6 Process Flow Diagrams / Material and Energy Balances

The Seller shall provide FDF with Process Flow Diagrams (PFD) as well as material and energy balances of the full-scale remediation facility for the systems outlined in Table F2. The PFD's and material and energy balances shall consider the main treatment process as well as all pre-treatment steps and secondary waste streams.

C.4.3.7 Cost Estimates

The Seller shall provide FDF with a cost estimate of the pre-treatment and main process items outlined in Table F2 or specified in the Design Data section.

C.4.3.8 Radon Control

Control and containment of radon gas is a consideration of the full-scale remediation facility preliminary design data. For Design Basis only, the Radon Control System (RCS) is designed to handle approximately 500 standard cubic feet per minute (scfm) of air from the pre-treatment, post-treatment, and process equipment. The Seller may propose a process off-gas train over 500 scfm, but this would require redesign of the RCS by FDF. Producing an off-gas stream in excess of what the current RCS design can handle will increase the size requirements of the RCS equipment, with an increasing life cycle cost of the proposed technology. These additional costs shall be included in the overall cost estimate and shall be considered in the subsequent evaluation of the proposed technology.

Therefore, choice and design of the full-scale equipment shall consider minimizing air flow from the process equipment streams. The ramification of this requirement is that either (1) airtight equipment design or (2) maintaining negative air-pressure in the equipment to prevent air flow (and radon gas) into the work area becomes a necessary design parameter. If the Seller proposes the installation of process equipment in a controlled air room because of concerns for meeting the above requirements, the room shall be considered part of the 500 scfm allotment.

C.4.3.9 Industrial Hygiene Requirements

The nonradioactive surrogates, developed to simulate the actual Silos 1 and 2 residue, contain heavy metal constituents; therefore, the surrogates shall be treated/processed accordingly. During testing, if dust or secondary waste control is identified as a problem, observations shall be noted in the test log and discussed in the final report. Accordingly, design data to be supplied for the full-scale remediation facility shall also address dust control. Process and design data regarding toxic materials or chemicals to be used for the full-scale process shall be supplied by the Seller.

C.5 Reports

C.5.1 Weekly Reports

The one to three-page weekly reports shall contain, as a minimum, the following items:

A. Progress in respect to the Work Plan and schedule;
B Activities attempted during the period;
C. Results of all attempts, including failures (root causes);
D. Issues;
E. Conclusions;
F. Synopsis of weekly telephone conference; and
G. Plans for the next two (2) weeks.

C.5.2 Final Report

The draft of the final report shall be submitted for FDF review and concurrence. This report shall include, but is not limited to, the following information:

A. Description of testing;
B. Results of testing runs, including failures;
C. Downtime durations and causes, and corrective actions;
D. Chemical / Physical data to characterize the untreated surrogate slurries and treated residue;
E. Results of preliminary lab tests;
F. Conditions of experiments;
G. Observations;
H. Volume of treated surrogate produced;
I. Volume of secondary waste produced and requiring treatment;
J. Samples collected, conditions, and analytical data packages, log books;
K. Interpretation of the results;
L. The prescribed recipes/formulas with recommended allowable constituent variation;
M. Graphs showing interrelated key parameters;
N. Safety issues associated with the process;
O. Reliability of the process;
P. Implementation;
Q. Schedule elements for the full-scale remediation facility;
R. Cost elements for the full-scale remediation facility; and
S. Conclusions.

C.5.3 Telephone Conferences

In addition to weekly reports, the Seller shall participate in weekly telephone conferences with FDF project personnel and shall provide testing status and progress. Additional telephone conferences shall be conducted if testing activities require. Telephone conversation logs detailing subjects discussed shall be completed and included as an attachment to the final report. The weekly reports shall reflect the issues discussed during the teleconferences.

C.5.4 Testing Records

The Seller shall submit to FDF all batch sheets, analytical data packages, testing logs, and laboratory notebooks pertaining to the Proof of Principle Testing findings. Testing documentation shall be submitted to FDF as an attachment to the final report.

C.5.5 On-Site Meetings

The Seller shall attend one meeting at the FEMP to present the final report at the Seller's expense.

C.6 Deliverables

Table C6-1: Index of Deliverables Identified in Section C

Document / Activity	Document Required Codes	Reference Subsection
Work Plan	A	C.3.2.1
Testing QA/QC Plan	A	C.3.2.2
Weekly Reports	B	C.5.1
Telephone Conferences	E, F	C.5.3
Compound Assays	C	C.3.2.3
Sieve Tests on Chemical Compounds	C	C.3.2.3
Video Tapes of Demonstration Run	F	C.3.1
Testing Documentation	G	C.5.4
Analytical Data Packages	G	C.5.4
Archived Samples	G	C.4.2.2
Samples for FDF Durability Testing	H	C.4.2.1 & C.4.2.2
Design Data in the Final Report	G	C.4.3
Draft Final Report	G	C.5.2
Final Report	D	C.5.2

Document Required Codes

A In accordance with Seller-developed FDF-concurred schedule
B Weekly, within three days of the end of the testing week
C Two weeks prior to testing
D Two weeks after receipt of FDF comments on draft
E Weekly
F As testing activities require
G 38 weeks after award of contract
H When all durability samples identified in TableG1are collected

C.7 Project Schedule

Table C7-1 presents the key milestones for the Proof of Principle Project, which shall be incorporated into the Sellers' project schedule. The Seller shall include a completed schedule in the proposal to FDF.

Table C7-1: Key Milestones

Activity	Activity Duration (Weeks)	Project Duration (Weeks)
Award Contract	*	*
Prepare Work Plan and QA/QC Plan	*	*
FDF Review and Comment on Work Plan and QA/QC Plan	2	*
Address FDF Comments on Work Plan and QA/QC Plan	*	*
FDF Review and Comment on Re-submitted Work Plan and QA/QC Plan	1	*
Address Final Comments	*	*
FDF Reviews and Approves Work Plan and QA/QC Plan	1	*
Perform Proof of Principle Testing	*	*
Prepare Draft Final Report w/ Testing Documentation and Analytical Data Packages	*	*
FDF Review of Draft Final Report	2	*
Address FDF Comments on Draft Final Report	*	*
Submit Final Report w/ Archived Samples	*	*
Perform Presentation of Final Report	*	*

* Table is to be completed and submitted with proposal.